Final Report

A project under the Canada
New Brunswick Conservation
and Renewable Energy
Demonstration Program

RECYCLED ASPHALT PAVING
MCGIVNEY-ASTLE, N.B.
PROJECT MANAGEMENT
EASTERN PAVING LTD., DIVISION OF
MODERN ENTERPRISES LTD.,
MONCTON, N.B.
REPORT COMPILED BY
EASTERN PAVING LTD.
1983

Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

Conservation & Renewable
Energy Division
Energy Secretariat
P.O. Box 6000
Fredericton, N.B.
E3B 5H1
(506) 453-3897

Programme Canada/Nouveau-Brunswick de démonstration des économies d'énergie et des énergies renouvelables

Le Programme de démonstration des économies d'énergie et des énergies renouvelables est administré au Nouveau-Brunswick par le Secrétariat à l'énergie, en collaboration avec Energie, Mines et Ressources Canada. Ce programme tente d'abord de vérifier la fiabilité des techniques de conservation d'énergie, d'accroître la sensibilité du public envers ces techniques et, enfin, de favoriser la création d'emplois au sein des industries nouvelles ou déjà existantes.

Un grand nombre de projets de démonstration se sont avérés à la fois techniquement réalisables et économiquement attrayants.

Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

Division des économies d'énergie
et des énergies renouvelables
Secrétariat à l'énergie
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D I S C L A I M E R

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Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

New Brunswick Energy Secretariat

Asphalt Recycling

Eastern Paving Ltd.

Project Summary

Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

Project Location:
Ludlow
Northumberland County
New Brunswick

Project Manager:
Mr. J.B. Steeves
Eastern Paving Ltd.
Moncton, N.B.

Date:
July, 1982

Project Number:
2017

Status:
Completed

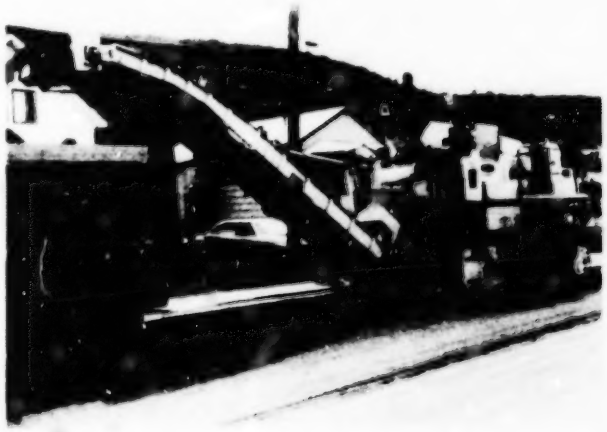
Technology:
Conservation - recycling

Sector:
Industrial

Province:
New Brunswick

Purpose:

To demonstrate conservation of a non-renewable resource by the hot recycling of reclaimed asphalt pavement.



Description:

The asphalt was reclaimed from 4.7 miles of New Brunswick Highway Route 8 between McGivney and Astle, transported to the project site at Ludlow where it was crushed, stockpiled and later mixed with new asphalt. The final component of the project involves laying 16,500 tons of asphaltic base material (50% of it reclaimed).

Contributors:

Canada-New Brunswick:	$75,000
Project Proponent:	$46,460

Expected Benefits/Savings:

Recycling two materials which are non-renewable (liquid asphalt and gravel) is expected to bring significant cost savings. Should have widespread application for public and private paving companies.

Further Information:

-booklet;
-slide presentation;
-on-site tours
-final report

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OR

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E3B 5H1
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Project Title:

Recycling Asphalt - Eastern Paving Ltd.

Economic Analysis:

Project Costs -

Capital Equipment & Installation	$116,460
Monitoring & Information Transfer	$ 5,000
Total demonstration cost	$121,460

Energy Impact- 20,000 tons of virgin asphalt mix costing ($9.90/ton) $198,000 are replaced by a mixture consisting of 10,000 tons of virgin asphalt and 10,000 tons of recycled asphalt pavement (RAP) costing ($6.61/ton) $132,200 resulting in an annual saving of $65,800 and an expected payback of 1.75 years.

Monitoring/Evaluation:

To be included in final report.

Technical Details/Specifications:

- Reclaim feeder bin and 60' feed conveyor installed at CNR ballast pit, Ludlow.
- Standard Havens Recycle Package installed on existing drum mixer plant.
- Production time for recycled mix is two weeks.
- Coneflight TM system used for recycling.
- Final total mix temperature of at least 270° F.
- A closed loop damper controller acts as safety feature and saves at least 5% fuel.

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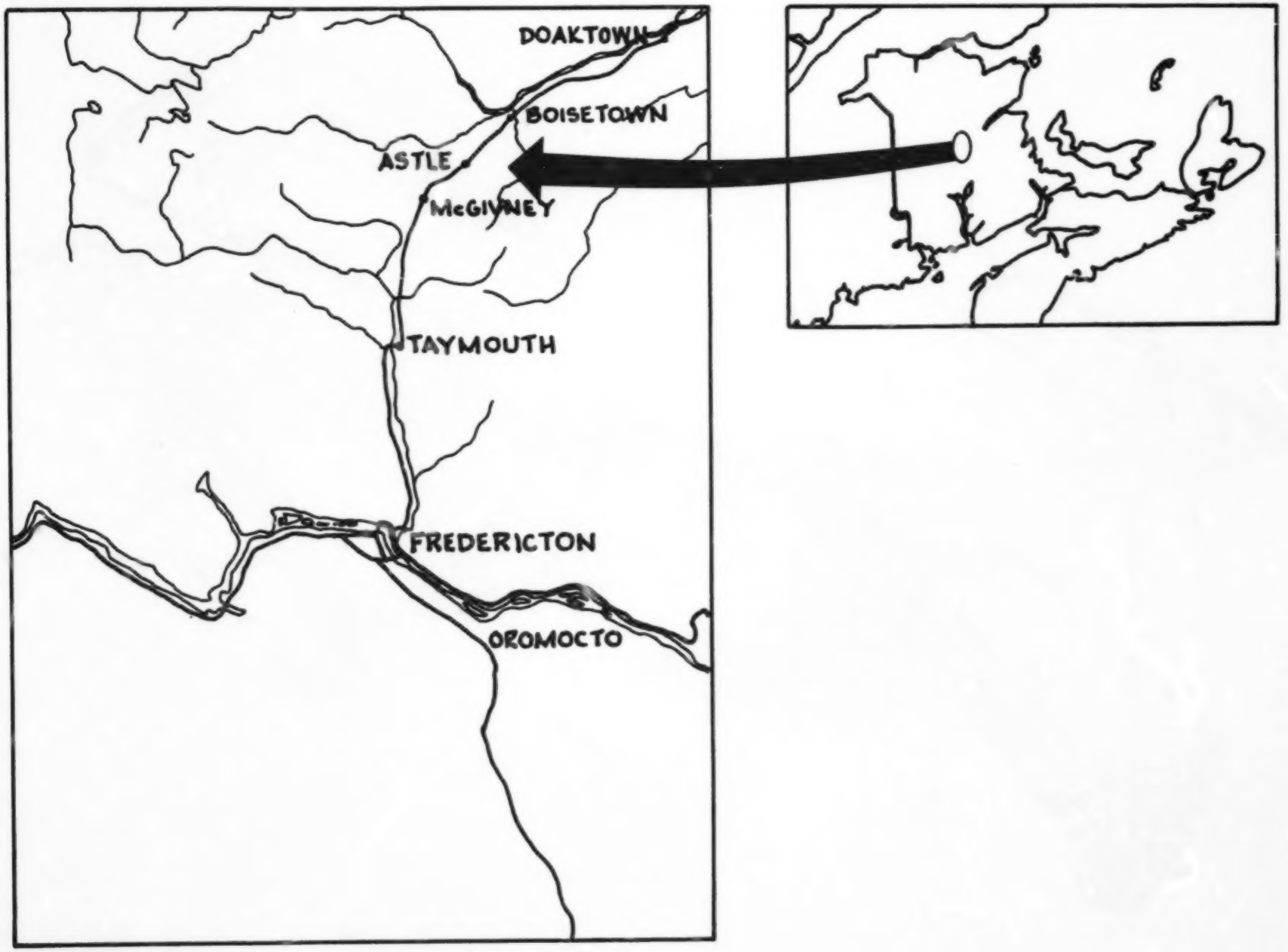
Appendix A: Schematic of Drum-Mixer

Appendix B: Asphalt Recycling Savings Calculator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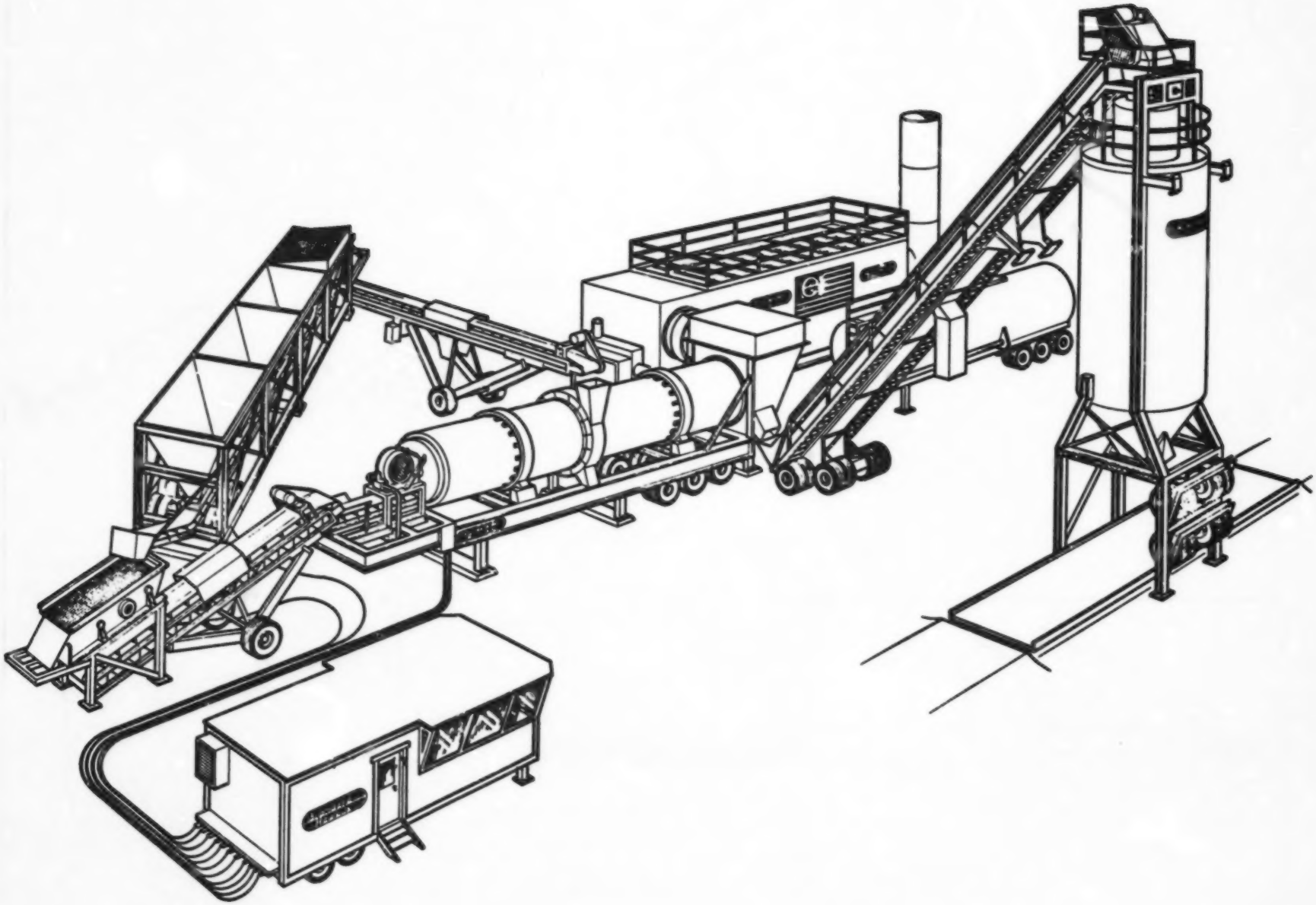


1. Propriety Notice

The "Modicon" Controller and the Standard Havens "Cone-Flight" are trade marks of the manufacturers and are covered by patents or have patents pending.

2. Executive Summary

In 1981 the New Brunswick Department of Transportation called for tenders on a 6.7km road project in central New Brunswick. Project specifications included recycling the existing pavement. The contract was awarded to Eastern Paving Ltd. of Moncton, which successfully applied to the Canada-New Brunswick Conservation and Renewable Energy Demonstration Program for financial assistance with the conservation-related project elements. The Program contributed $75,000 toward total costs of $132,897.

Modern Paving carried out the project with a recycling modification package for their Standard Havens Drum-Mixer. This package also was manufactured by Standard Havens. It includes a programmable plant controller that continuously monitors operations and ensures desired production rates and required mix proportions. The recycle package was installed in the field in two weeks by EPL personel, using engineering drawings supplied by Standard Havens. The controller was installed by EPL with on-site supervision by a Standard Havens technician. Feed bins and conveyors were fabricated or adapted by Eastern Paving and Apex Industries, also of Moncton.

The existing pavement was ripped, loaded onto trucks, delivered to the processing site, crushed and stockpiled with protection from rain. Samples of virgin aggregate, local sand and crushed, recycled asphalt paving were analysed by the N.B.-D.O.T. central laboratory in Fredericton. The lab

also tested possible mixes and ultimately provided an optimum design, which contained 50% recycled asphalt pavement. After inspection, the Department was satisfied the system would consistently and accurately deliver the mix components into the drum mixer within the tolerances of the job formula, and approval was granted to start production.

Production of the required 50/50 mix took 8 days. Production rates were well below expectations due to insufficient haul units and delays in sub-base preparation. No significant problems were encountre in either hauling or processing the reclaimed asphalt. Labor and equipment required to supply and service the plant were the same as for virgin mixtures. There was no disc rnable difference between the recycled product and virgin mixtures on visual inspection. No problems were encountered with spreading or compaction.

Project accounting indicates the 50/50 mix was 19% less expensive to produce than a 100% virgin mixture. In addition an amount of surplus reclaimed pavement almost equal to that used in the project remains stockpiled. With a doubling of the ownership cost to allow for maintenance and upgrading over a ten year period, and without consideration of the value of the stockpiled pavement remaining, the hardware investment shows a payback period of 2.5 years.

Environmental impact highlights the conservation of four non-renewable resources: asphaltic cement, gravel, sand and furnace oil. Environmental pollution was slightly more than expected but not serious, in the form of blue smoke emissions. This is expected to be greatly reduced or eliminated by minor plant modifications and increased production rates.

Elements of concern for future pavement recycling projects are sub-base contamination when removing old pavement; estimating the gradation of aggregates in recycled pavement and consequent virgin aggregate requirements; the moisture content of recycled asphalt paving; stockpile consolidation; crushing procedures; and moisture content allowable in the product mix.

From the standpoint of the contracting agency and of the contractor, the project was a complete success. The recycle option is now being looked at by the Department of Transportation on all highway reconstruction projects, and the Department is now stockpiling recyclable paving for future use in recycle mixes.

Sommaire exécutif

En 1981, le ministère des Transports du Nouveau-Brunswick a lancé un appel d'offres pour la réalisation d'un projet relatif à un chemin de 6,7 km, situé dans le centre de la province. Les devis du projet comprenaient le recyclage de l'asphalte actuelle. Le contrat a été adjugé à la Eastern Paving Ltd. de Moncton, qui a reçu une aide financière dans le cadre du Programme de démonstration des économies d'énergie et des énergies renouvelables pour les phases du projet reliées à l'économie. Le programme a défrayé 75 000 $ du coût total qui s'élevait à 132 897 $.

Pour réaliser ce projet, la Eastern Paving s'est servie de matériel de recyclage dans son mélangeur à tambour Standard Havens. Ce matériel, qui est également fabriqué par Standard Havens, comprend un combinateur de couplage programmable servant à contrôler constamment les opérations et à assurer le taux de production voulu ainsi que les doses de mélange nécessaires. Le personnel de la Eastern Paving a mis deux semaines pour installer le matériel de recyclage sur le terrain et il a utilisé les plans techniques préparés par la Standard Havens. Eastern Paving a installé le combinateur de couplage sous la surveillance d'un technicien de Standard Havens. Eastern Paving et Apex Industries, également de Moncton, ont fabriqué ou adapté les caissons d'alimentation et les convoyeurs alimentateurs.

L'asphalte déjà en place a été arraché, chargé sur camion, livré au lieu de transformation, concassé et stocké de façon à ce qu'il ne soit pas abîmé par la pluie. Le laboratoire central du ministère des Transports du Nouveau-Brunswick, situé à Fredericton, a analysé des échantillons d'agrégat neuf, de sable provenant de la région et d'asphalte concassé et recyclé. Il a également mis à l'essai des mélanges évantuels et a finalement trouvé le dosage optimal, qui

Sommaire exécutif (suite)

contenait 50% d'asphalte recyclé. Après avoir mené une enquête, le ministère s'est dit convaincu que le système introduirait les composants du mélange de façon régulière et précise dans l'appareil mélangeur à tambour à l'intérieur des tolérances de la formule utilisée pour les travaux et il a approuvé la mise en marche de la production.

Il a fallu 8 jours pour produire le mélange 50/50 requis. Le niveau de production s'est avéré considérablement inférieur à celui qui avait été prévu, en raison du nombre insuffisant de véhicules de transport et du retard connu lors de la préparation de la couche sous-jacente. Le transport et la transformation de l'asphalte récupéré se sont généralement bien déroulés. Pour ce qui est de la mise en service des installations, il n'a pas fallu plus de main-d'oeuvre et d'équipement que lorsque l'on utilisait des mélanges neufs. A l'oeil nu, le produit recyclé et les mélanges neufs sont semblables. L'épandage et le compactage se sont déroulés sans aucun inconvénient.

La comptabilité du projet indique que la production du mélange 50/50 a coûté 19% moins cher que celle d'un mélange neuf à 100%. De plus, un excédent d'asphalte récupéré presque égal à la quantité utilisée pour le projet reste stocké. En tenant compte du doublement des frais de propriété destinés aux travaux d'entretien et d'amélioration pour une période de dix ans et en excluant la valeur de l'asphalte stocké qui reste, l'investissement en matériel indique un recouvrement de 2,5 ans.

L'impact sur l'environnement met en lumière l'économie de quatre ressources non renouvelables: le ciment asphaltique, le gravier, le sable et le mazout. Quoique légèrement supérieure à ce que l'on avait prévu, la pollution de l'environnement n'était pas critique. Elle s'est présentée sous forme

Sommaire exécutif (suite)

d'émissions de fumée bleue. Ce problème devrait être résolu ou atténué considérablement grâce à l'apport de modifications mineures à l'installation et à l'augmentation des taux de production.

Lors des prochains projets de recyclage de l'asphalte, il faudra s'intéresser aux points suivants: la contamination de la couche sous-jacente lors de l'enlèvement du vieil asphalte; l'évaluation de la granulométrie des agrégats de l'asphalte recyclé et les besoins résultants en agrégats neufs; la teneur en humidité de l'asphalte recyclé; l'intégration du stock de réserve; les méthodes de concassage; et la teneur en humidité acceptable pour de la gamme des produits.

Du point de vue de la firme et de l'entrepreneur, le projet a été un véritable succès. Le ministère des Transports envisage maintenant d'utiliser de l'asphalte recyclé pour tous les projets de réfection de routes. Il stocke actuellement de l'asphalte recyclable qui sera utilisé plus tard pour produire des mélanges de recyclage.

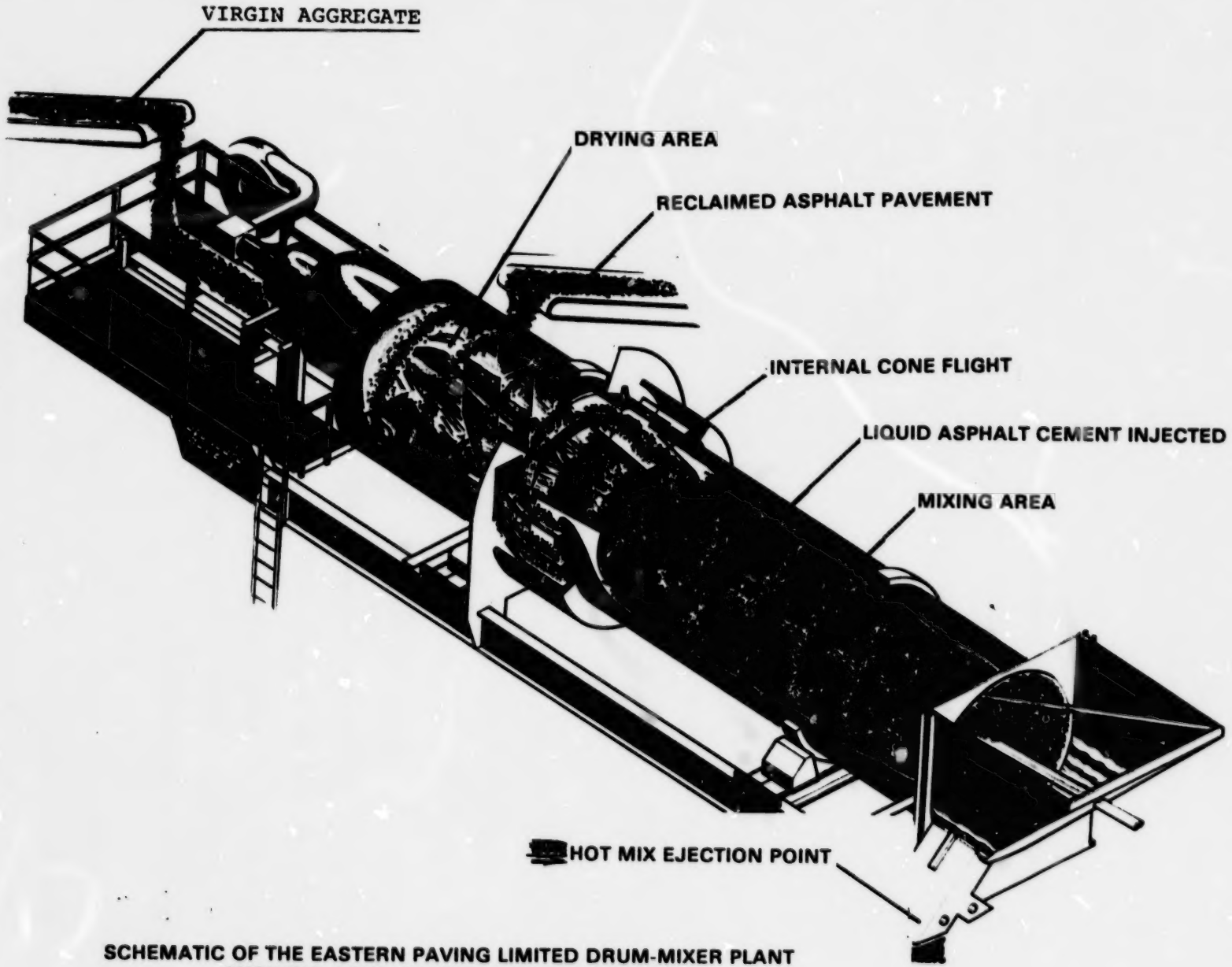
3. Introduction

In 1981 the New Brunswick Department of Transportation decided to explore hot recycling of asphalt pavement (RAP) as an economical alternative to pavement overlays when upgrading an existing highway or street.

In highway or street construction virtually all components of flexible asphalt pavement structures have recycle potential. The rising cost of liquid asphalt cements and quality aggregates is making recycling more attractive. While definitive data is unavailable, one source estimate that there are 13.5 billion tonnes of recyclable pavement structures in place having a value of $150 billion in 1982.

However, in 1981 the recycling of asphalt pavement had not yet been demonstrated in New Brunswick. The Provincial Department of Transportation therefore called for tenders on a 6.7km road project in which pavement recycling was required. Consideration was given to conventional pavement overlay design versus hot recycling. Comparison of the two alternatives, strictly on a completed cost basis, indicated no appreciable cost saving to be realized through hot recycling. However, the savings in resource conservation, longer pavement life expectancy, and value of the surplus relaimed asphalt pavement for use in future projects made hot recycling the more attractive option.

The contract was awarded to Eastern Paving of Moncton, New Brunswick, which subsequently submitted a proposal for assistance to the Canada-New Brunswick Conservation and Renewable Energy Program. The project was approved and assistance of $75,000 was provided toward project costs.



SCHEMATIC OF THE EASTERN PAVING LIMITED DRUM-MIXER PLANT
SHOWING CONE-FLIGHT™ RECYCLE SYSTEM

4. Technical Description

The Roadway

The recycling project was carried out during the upgrading of a 6.7km section of Provincial Route #8 located 64km north of Fredericton, between McGivney Junction and Astle. Approximately 14,500 tonnes of asphaltic base containing 50% RAP were placed. In addition the 8.5m roadway was widened to 10.9m by setting the ditches back and extending the existing shoulders to the specified width. Obsolete timber culverts and cross ways were replaced at the same time.

The roadway pavement had been constructed in the 1940's and was subject to heavy truck traffic, the Boiestown and Doaktown areas to the east being major sources of pulpwood and lumber products bound for markets in other parts of the Atlantic Provinces and the New England States. Repeated heavy wheel loadings had resulted in extreme differential settlement in the pavement structure in both the longitudinal and transverse profiles. The advanced age of the asphalt pavement had also led to heavy transverse cracking. During the winter, frost action peaked the cracks to a point that created an extremely rough driving surface.

Equipment Retrofit

Recycled asphaltic concrete has been produced with varying degrees of success by batch, continuous, and drum-mixer type asphalt plants. The drum-mixer has the advantage over the other types of being able to accomodate a higher ratio of reclaimed asphalt pavement to virgin material. This is due to the method of heat transfer used in the drum-mixer plants.

Heat transfer between virgin aggregates and RAP allows a recycled mix to be produced without subjecting the RAP to an open flame, thus eliminating the blue smoke emitted when an asphalt product is burned.

In the drum-mixer, the most common heat transfer method is to super-heat the virgin aggregates in the front, or burner end of the drum. The RAP is introduced at a point mid-way down the drum beyond reach of the burner flame. Liquid asphalt, as required to rejuvenate the old A.C. in the RAP and to coat the virgin aggregates, is also added at this point. The heat transfer from the new aggregate to the RAP takes place as the two materials tumble together in the mixing area of the drum (See Appendix A).

To convert Eastern Paving's 836 model Standard Havens Drum Mixer from a plant using only 100 percent virgin materials for asphalt mix production, to a unit with both recycle and conventional mix capabilities, the following components were added or altered.

1) Additions

   (a) single cold feed bin
   (b) belt conveyor with load cell
   (c) Standard Havens Cone-Flight ™ recycle package

2) Alterations
   (a) plant controls
   (b) drum flighting

Submissions from several asphalt plant manufacturers for conversion kits were received and studied. The final choice was the Standard Havens Cone Flight™ system and Modicon Programmable Plant Controller.

This was primarily due to the fact that the Standard Havens recycle package and Modicon controls were designed, manufactured and test proven to operate on the Model 836 Drum-Mixer, or other Standard Haven models, and could therefore be installed without major changes to the present plant or control panel structure.

Early in the decision-making process, it was determined that a substantial saving could be realized by using local labour and materials to manufacture the feeder bin and belt conveyor rather than purchase pre-built units.

Standard Havens co-operated by adapting their controls to these made-in-New Brunswick Units.

The installation of the Standard Havens recycle package, the Modicon controller, and controller programming required approximately 10 working days.

A description of the additions and alterations and their basic functions, are as follows:

Additions

(a) Single Cold Feed Bin

This unit required special design configurations in order to consistantly feed reclaimed asphaltic concrete without bridging or plugging taking place.

An existing aggregate cold feed bin was adapted by Eastern Paving Limited, and Apex Industrial personnel. The side and back walls were steepened to prevent material bridging. The feed belt was

(a) Single Cold Feed bin (continued)

widened from 18" to 30" and the feed area designed in such a way that a wedge-shaped "slug" of material would be drawn from the bin to eliminate plugging of the feeded opening.

The feeder is driven by a 7.5 h.p A.C. motor with a Parajust variable cycle speed control.

(b) Belt Conveyor & Load Cell

The 60' long belt conveyor was fabricated by Apex Industries Ltd. of Moncton, with design specs and materials supplied by Eastern Paving Limited.

The Ramsey 30" load cell and belt speed sensor was supplied by Standard Havens Inc. as part of the recycle package.

Installation and calibration of the load cell and controls was carried out in the field by Eastern Paving Limited personnel.

(c) Standard Havens Recycle Package (Cone-Flight™)

The recycling system is a centre entry type designed to feed processed, reclaimed asphaltic pavement into the mixing area of a drum mixer asphalt plant.

The inlet chute and bulkhead assembly is mounted to the main frame along with a divert chute and dust seals.

The outer collar of 1/4" steel plate is connected directly to the drum shell and rotates as a unit with the drum. Internal spiral flights direct material into entry ports cut in the drum shell.

The Cone-Flight™ is mounted inside the drum. Reduced cross-sectional area and bucket-type flights on the interior of the cone produce a dense veil of heated virgin aggregate to protect the RAP from direct contact with the burner flame.

The recycle package was installed in the field during the first two weeks of May by E.P.L. personnel, using engineering drawings supplied by Standard Havens Inc.

Alterations

(a) Plant Controls

The feeding, weighing, metering, sequencing, and monitoring for automatic blending or virgin aggregate, reclaimed material and new asphalt cement are handled by a Modicon 484 programmable controller.

A production rate in tonnes per hour is pre-set by a thumb wheel. The controller then selects the flow rate of different sizes of virgin aggregate required (up to 4), monitors the total virgin aggregate by a load cell on belt conveyor, delivers a corresponding predetermined percentage of reclaimed material by controlling the R.P.M. of RAP bin feeder. The tones per hour of this product are monitored by a conveyor belt load cell. The system then meters in the pre-set percentage of new liquid asphalt cement required by the mix design.

These materials are automatically delivered in sequence and proportion as determined by a design mix formula.

(a) Plant Controls (continued)

The system receives its input from digital thumb wheels on which are set the production rate in t.p.h.; percentage of RAP in final mix; percentage of residual asphalt cement in the RAP; percentage of total A.C. in final mix; percentage moisture in RAP; percentage moisture in virgin aggregate; specific gravity of A.C.; A.C. on time and off time.

L.C.D.'s display actual total production rate in t.p.h., A.C. being added in t.p.h., virgin aggregate in t.p.h., and RAP in t.p.h.

The Modicon then monitors the critical area 30 times per second and makes any required adjustment in material flows to maintain desired production rates and ensure that the mix proportions are within the specified tolerance, e.g. - the A.C. must be accurate to ± 2 percent.

The Modicon system was installed by E.P.L. with on-site supervision by a Standard Havens Inc. technician. E.P.L. later purchased a C.R.T. programming panel in order to more easily make program changes if required.

In the process of altering the plant control panel and programming the Modicon controller, the plant control functions and displays were converted to the metric system.

The cost making the conversion to metric was minimal when carried out at this time.

Reclamation, Crushing & Stockpiling of Pavement

Several methods which have been used to remove asphalt pavement from the roadway for recycling were studied. Some of these include ripping and tramping with a crawler dozer; removing and loading with large backhoes; cold planing; and removing and loading with rubber-tired loaders.

The dozer method was discounted because of the danger of excess contamination of the RAP by the underlying sub-base material. Backhoes were not available and required more room to operate than the road width would allow. Cold milling would not be economical due to the depth and would probably produce oversize material (over 38 mm), which would require additional crushing.

The decision finally arrived at, based on equipment availability, etc., was to use a grader with a scarifier-mounted ripper tooth to cut the lane longitudinally at approximately 1 m wide intervals. The ripper tooth was kept to a depth which would just penetrate the 125 mm thickness of the pavement.

The broken asphalt, containing pieces as large as 1 m square, were loaded onto trucks by a crawler-mounted front end loader, and hauled to the plant site at Boiestown for processing.

Due to the size of the reclaimed material, a Primary Crusher was required to reduce the pavement to a size which could be handled by a Secondary Jaw and Roll Crusher.

The RAP was crushed to 100 percent passing a 38 mm square screen. No major problems were encountered in processing the old pavement through the crushing train with hourly production rate going as high as 200 t.p.h.

The crushed RAP was stockpiled with loaders to a height of approximately 10 m. The job specs required that the RAP pile be kept covered when not in use, to prevent ingress of moisture. A 27 m X 38 m fiber-glass reinforced plastic tarp was used for this purpose.

Consolidation of the crushed material, by stockpile height and tramping with the stockpile loaders, was very slight. This was probably due to the advanced age and oxidation of the residual asphalt cement.

Some problems were encountered trying to maintain the plastic stockpile cover in high winds and between production days.

Mix Design & Plant Calibration

Samples of virgin aggregates, crushed and stockpiled in the fall of 1980, local sand, and crushed RAP were delivered to the N.B.-D.O.T., Central Lab at Fredericton, for mix design.

Extraction tests carried out on the crushed RAP indicated a residual A.C. content of 4.4 percent. This was less than the amount obtained from core testing. The reduced A.C. content was attributed to contamination of the RAP by the roadway sub-base material which adhered to the asphaltic concrete during the removal operations.

Labratory mixes containing proportions of RAP varying from 40 percent to 55 percent were designed and tested. The optimum design finally chosen contained:

50 percent RAP;
34.7 percent of 6.4 mm - 25 mm crushed virgin gravel;
11.8 percent of 9 mm - 6.4 mm local sand;
3.5 percent new asphalt cement.

During the two week mix design period, the drum mixer asphalt plant was moved to the job site and erected.

Programming of the Modicon Controller and calibration of the virgin aggregate cold feed bin. The RAP feed bin; the belt scale load cells on the aggregate conveyor and the RAP conveyor; and the asphalt delivery pump, was carried out and checked by the Department of Transportation inspectors. Assured that the system would consistantly and accurately deliver the mix components into the drum mixer within the tolerance of the job formula, approval was granted to start production on July 13th.

Placing of Recycled Hot Mix

The recycled hot mix was placed on the prepared road surface using a standard paving train, in this case: 2 - SA41 Spreaders
1 - Dynapac 50 Vibratory Roller
1 - Raygo 404 Vibratory Roller

5. Performance of the System

Production of the 13,500 tonnes of recycled mix covered an eight day period. Daily production rates ranged from a low of 1000 tonnes to a high of 2,400 tonnes. The average daily rate of 1,700 tonnes was well below expectations and plant capacity. The inability to obtain sufficient haul units and delays in sub-base preparation forced the operation to run at approximately 100 t.p.h. below desired production levels.

No significant problems were experienced in handling and processing the reclaimed asphalt. The amount of labour and equipment required to supply and service the plant was the same as when producing 100% virgin asphalt mixes. It was noted that at the end of the production day, care must be taken to ensure

that the RAP feeder bin is completely emptied. Reclaimed material left overnight or longer can form a semi-solid mass resulting in a plugged feed system.

Visual inspection of the recycled mix indicated no discernable difference between the recycled product and a mix containing 100% virgin materials. No problems were encountered with spreading the mixture or obtaining specified compaction.

The project required 13,500 tonnes of asphaltic concrete base at a 50-50 ratio of RAP to new materials. TABLE 1 compares the quantities of new materials used in recycling with a similar amount of base mix using 100 percent virgin resources.

TABLE 1

	100%	50/50	
RESOURCE	Virgin Mix	Recycled Mix	Saving
Virgin Aggregate	12,730 tonnes	6,200 tonnes	6,530 tonnes
Asphalt Cement	771,700 litres	474,000 litres	297,700 litres
Furnace Oil	104,490 litres	96,390 litres	*8,100 litres

* Fuel savings on this project were determined by maintaining a record of the amount of furnace oil consumed during the heating and drying operations for the recycled mix and for the 100 percent virgin material surface course. The moisture content of the mix components were comparable in both cases.

The reclaimed pavement (6,800 tonnes) was made up to 4.4 percent asphalt cement and 95.6 percent aggregate. The A.C. content of the RAP would have been higher, if the removal process could have been carried out without contamination from sub-base aggregate adhering to the larger pieces of RAP.

In addition to the 6,800 tonnes of RAP used in the hot recycling project, approximately 6,000 tonnes of surplus reclaimed material was stockpiled for use on future paving projects.

Further energy conservation was realized from the project by eliminating the transportation from Saint John of the liquid asphalt cement contained in the RAP, and haulage of virgin aggregate from the source to the plant site.

6. Project Cost Accounting

Total project cost:	$132,896.92
Contribution by Canada-New Brunswick Conservation and Renewable Energy Program:	$ 75,000,00
Contribution by Eastern Paving:	$ 67,896.92

These expenses break down as follows:

(a) Reclaimed material feeder bin	$16,091.56
60' feed conveyor	11,868.94
recycling package (incl. automatic damper control)	76,627.01
administration and project monitoring	28,309.41
	$132,896.92

(b) labor	$47,038.09
materials	84,168.83
equipment	1,690.00
	$132,896.92

7. Cost-Benefit Analysis

Dollar Savings per tonne

The project experience with conservation of materials and actual costs at completion is shown in Table 2 below, comparing costs for 50/50 recycled mix vs. 100% virgin mix.

TABLE II

COST COMPARISON -50/50 Recycled vs 100% Virgin Mixes/tonne

ASPHLT. MIX COMPONENT	COMP. CST. AT ASPHLT. PLANT	% OF RECYCL. MIX	50/50 RECYCL. MIX	% OF VIRG. MIX	100% VIRG. MIX
Virgin 1" Stone	$ 5.45/t	34.7	$ 1.89	47.3	$ 2.58
Virgin 3/8" Sand	2.20/t	11.8	0.25	47.2	1.04
Reclaimed Asphalt	6.86/t	50.0	3.43		
Liquid Asphalt	276.46/t	3.5	9.68	5.5	15.20
TOTALS		100%	15.25	100%	18.82
		$3.57 Cost Saving			

Component cost figures shown in Column 2 represent the actual cost to the Department of Transportation either as part of a bid price, or as a cost of material as supplied by the Department (eg. Liquid Asphalt Cement).

All transportation, excavation, processing, and stockpiling in preparation for mixing is included. Weather protection of the crushed RAP is also included.

Overhead costs associated with paving projects have not been included, however, these would not be higher for recycling than for producing virgin mixes.

In addition to the saving in the cost of materials, the project generated a surplus of approximately 6,000 tonnes of RAP.

The value of the liquid asphalt in the stockpiled surplus at 1981 prices would be 6,000 X 4.4% AC X $276.46/tonne = $72,985. The aggregate value in the RAP can usually be said to be approximately equal to the cost of reclaiming and processing the old pavement (Table II, Column 2).

(See Appendix for information on the "Asphalt Recycling Savings Calculator" available from Standard Havens.)

Payback analysis on equipment

The total ownership cost of the plant conversion for this project, using a 30 percent per year depreciation and assuming an average yearly interest of 17.5% calculated on the undepreciated balance, would be ... $159,894.00

Over a 10 year period, some components of the system would be replaced due to wear, technology advances etc. The cost of these maintenance areas would probably be nearly equal to the original total package cost due to inflation and other factors, or $159,894.00

Total ten year cost therefore is $319,788.00

Assuming, conservatively, production of 300,000 tonnes of recycled asphalt over ten years, the cost of equipment over this period is therefore ..... $1.07/tonne.

By Table II, the material cost saving over virgin mix is $3.57 per tonne (all differential costs included as noted following Table II.)

At production 30,000 tonnes per year, material saving is	$107,100/yr.
Equipment cost is	31,980/yr.
Actual savings are	75,120/yr.
Initial investment was	$159,894

Payback on investment is 159,894/75,120 or 2.5 years.

Note: If the value of excess relaimed material is considered, payback period is considerably less.

Value of excess reclaimed asphalt paving

Project experience indicated a 6000t surplus with 6800t old material used. For each tonne of reclaimed material used, .88t reclaimed material is excess. If annual production is 30,000t of 50/50 mixture then 15,000t of this is reclaimed material, and excess equals .88 X 15,000t or 13,200t.

Stone and sand in excess equals 95.6% or 12,619t, and is valued at $7.65/t or $96,535.

Asphalt in excess equals 4.4% or 580t, and is valued at $276.46/t, or $160,568. Total value of excess for one year's production is $257,103. Of course, this excess is only of value if it can be used. If all is used, total savings per year are $332,222. Payback is .48 years.

Product value relative to ownership and maintenance costs

Savings can also be calculated as the number of tonnes of recycled asphalt produced minus ownership and maintenance costs.

The cost differential between virgin mixes and recycled mixes varies according to many factors. The greatest saving would be in an area where a high percentage of RAP was available having a high A.C. content and high virgin aggregate costs ... e.g. - 70 percent RAP with 6.5 percent A.C.

The lowest savings would be available when producing a recycled mix with a low (25%) RAP content, containing a low A.C. quantity (4%).

However, application of either of these extremes produces a production cost saving in excess of the ownership and maintenance costs.

8. Environmental Impact

The major environmental concern with hot recycling is the emission of "Blue Smoke". The blue smoke is created when the liquid asphalt in the reclaimed asphaltic concrete comes in contact with the burner flame.

The Cone Flight™ system produced by Standard Havens, is designed to eliminate the contact between the burner flame and the reclaimed asphalt. This is achieved by concentrating the virgin aggregate veil as it passes through the cone portion of the drum.

During recycle production on the McGivney Project, some blue smoke was observed, however, the visual density was well within the tolerances allowed by the N.B. Department of Environment.

Blue smoke production was attributed to the low plant production rate, during which the quantity and density of the virgin aggregate veil was not sufficient to completely block the burner flame from contact with the reclaimed material.

Flighting changes will be carried out prior to the next recycling project in an effort to thicken the aggregate veil at a point nearer the burner flame. The flight alterations and anticipated higher mix production rates should greatly reduce or eliminate blue smoke emissions.

On the positive side, the aggregate resource saving in a recycling operation is quite significant. Quality aggregates are fast becoming a rare resource. This fact coupled with an increasing reluctance on the part of the public to allow gravel or quarrying operations, particularly in urban areas, makes the recycling option environmentally attractive.

9. Information Transfer

During the period of time involving plant erection, calibration and recycled mix production; several interested parties representing contractors, equipment manufacturers, and the Provincial Government, visited the project site.

The number of people visiting the site was below expectation. However, the short duration of actual mix production time may have caused scheduling problems with some individuals.

Those who did visit the site included:

- N.S. Paving Contractors:
Mr. Vincent Dillman, President, Dillman's Enterprises
Mr. Carl Potter, Pres./Gen. Mgr., Municipal Spraying & Contracting Ltd.
Mr. Scott Weeks, Pres., S.W. Weeks Construction Ltd.

- N.B. Paving Contractors:
Mr. Donald Hawkes, Maintenance Super Diamond Const.
Mr. Carl Bleakney, C.E.T. - North Shore Const. Ltd.

- Asphalt Equipment Sales Representatives:
Atmus Ltd. (Barber-Greene Co.)
Blackwood Hodge Ltd. (Iowa Manufacturing Ltd.)

- New Brunswick Department of Transportation:
The large number of representatives from all levels of the N.B. - D.O.T. illustrated the interest which the Department had in the recycle process from the RAP recovery through the mixing and placing operations.

The project also received National coverage through the Department by being included as part of a slide presentation to the Roads & Transportation Association of Canada - 1981 Annual Meeting.

A technical sales video tape of the plant in action was produced during August, 1981 by Standard-Havens Canada Ltd. The filming was carried out at Kouchibouguac, New Brunswick, where the Recycle Plant was located following the McGivney Project. At the Kouchibouguac site the plant produced 53,000 tonnes of asphaltic concrete base containing 17% - 25% RAP for a 14.5 km section of Provincial Highway No 11.

Although the 20 minute film is sales oriented, a good deal of technical data was recorded concerning both the McGivney and Kouchibouguac projects. Of particular technical interest is the interview with the Provincial Asphalt Engineer, Maurice Bourgeois. Mr. Bourgeois commented to a great extent on the recycled asphalt mix design, plant calibration, and quality control aspects of the two projects. Included on the film are interviews with David Vautour, the N.B. - D.O.T. Plant Inspector on both projects; J.B. Steeves, Manager of Eastern Paving Limited; and Project Co-Ordinator, Lloyd Giggie.

The video tape has been shown to selected audiences at the 1982 National Asphalt Paving Association Annual Convention is San Francisco; at the Quebec Road Builders' Convention; The New Brunswick Road Builders' Convention in February, 1982; and the City of Moncton Manager and Engineering staff.

The film has also been viewed by numerous asphalt producers in Canada and the United States during sales promotions by Standard Havens.

Locally, Eastern Paving Limited has been actively promoting the conservation and recycling of "waste" asphaltic concrete with municipalities within a 80 km radius of Moncton. The "waste" product is generated through street and utility upgrading or reconstruction.

Letters were sent to the municipal managers and engineers in the area. An informal seminar was held with representatives from the Towns and Cities at the Moncton City Hall. At the seminar, slides and films showing the economic, aesthetic, and environmental advantages of asphalt reclaiming and recycling were viewed.

Since Eastern Paving Limited completed the recycling projects, inquiries seeking information or technical assistance have come from Canadian cities as far away as Victoria, British Columbia; from the Federal Ministry of Transport, Maritime Regional Office; and from C.F.B., Gagetown, N.B.

Further to the technical information and promotion already given out, copies of this report will be circulated throughout the Atlantic Provinces and other parts of Canada. The Standard Havens "Asphalt Recycling Savings Calculator" will be attached to the reports as a guide to fast, simple recycle savings calculations.

10. Conclusions and Recommendations

Recycling of RAP involves a great deal more than simply placing processed reclaimed asphalt into a feed bin and passing it through a converted asphalt plant. This phase, in fact, is probably the area which requires the least attention. Asphalt equipment manufacturers have, over the past five or six years, put a tremendous effort into developing controls, RAP feed systems, heat transfer, and mixing components for the various makes of asphalt plants. The systems which they have developed are able to take the RAP from the feeder through the plant, combine it with new virgin aggregates and asphalt, producing a finished product which can meet specified gradation, A.C. content, air void, and stability requirements consistantly.

That this technology was available, was successfully demonstrated on the McGivney project. However, there are other factors that will ultimately effect the finished product. Close attention must be given to these factors in order that asphalt recycling can remain an economical alternative and quality product.

Experiences from the McGivney project indicate the following factors require special attention:

RAP Removal - on total depth removal projects such as McGivney, contamination of the RAP by the underlying sub-base must be kept to a minimum. To do so, requires that care be taken during the ripping and loading operation. On this project, the sub-base had been primed prior to paving. This caused a fair amount of unavoidable contamination with the primed thickness (25mm) of sub-base clinging to the larger slabs of RAP. Contamination can also occur in the stockpile areas with the loader picking up material from the stockpile base. On this project, contamination from sub-base and stock piles lowered the effective A.C. content of the RAP from 5.5 to 4.4%.

Virgin Aggregates - when bidding on a recycling project, the requirement for virgin aggregates has to be determined by the contractor. This can be a high risk area especially should the job location dictate that a Portable Asphalt and Crushing Plant is required.

Gradation of the extracted aggregates from test cores would be available. However, this gradation is as the aggregates exist in situ. The contractor must try to determine what this gradation will look like after the RAP is processed. From this determination the contractor will then calculate the virgin aggregate requirements for the completed asphalt mix. Only with time and experience will the asphalt producer be able to more accurately predict the virgin aggregate gradations required to supplement various types and percentages of RAP.

Moisture Content of RAP - This is a very critical area of concern in the recycling process. The moisture content of the McGivney RAP averaged 2.3% somewhat higher than expectations. Estimated from Ontario and the United States experiences indicated 1 - 1.5% moisture contents should be normal. The advanced age of the asphalt pavement, the extent of the cracking in the road surface, coupled with an abnormally wet period prior to the RAP removal probably contributed to the higher-than-normal moisture content.

With the drum mixer, extra moisture had very little effect on the hourly production, but it did require higher than expected burner fuel consumption.

With a Batch Plant recycling operation, this extra moisture would have a serious effect on the plant output.

To prevent the ingress of moisture, the stockpile of crushed RAP was covered with a fiberglass reinforced plastic tarp. This requirement was part of the job specifications issued by N.B. - D.O.T.

Stockpile Consolidation - No problems were encountered on this project. The crushed RAP was stockpiled approximately 10m high with front-end loaders. However, the loaders caused very little consolidation. This was probably due to the low penetration and low percentage of A.C. in the RAP.

RAP Crushing - this area caused considerable concern going into the project. However, other than the slab size removed from the road, which required a large primary crusher for reduction to 3" size, the material crushed very easily. Even on 30° C + days, very little compaction in the jaws occured. Once again, this was probably attributable to the condition of the A.C. in the RAP.

Placing - when the project was being planned, the intention was to leave up to 1% moisture in the recycled mix as per the Department of Transportation, Province of New Brunswick specifications. However, it was found that the retained moisture caused the road surface to flush under traffic load. For this reason, the recycled mix had to be placed with 0 - 0.5% moisture, as with normal virgin mixes.

This required a higher mix temperature than estimated and a correspondingly higher fuel oil requirement. TABLE 1 shows that even with the fuel consumption being more than estimated, the end result still showed a saving in fuel oil over 100% virgin mixes.

Conclusions - From the standpoint of the contracting agency, and the contractor, the McGivney project was a complete success. Since the completion of this project and the Kouchibouguac contract, the Department of Transportation, Province of New Brunswick is convinced of the economic value of asphalt recycling. The recycle option is now being looked at on all highway reconstruction projects. In addition, all asphaltic concrete removed from Provincial reconstruction jobs or other sources, is being stockpiled for future use in recycled mixes.

In general, the McGivney Asphalt Recycling Project served to identify and confirm that:

- Technology is available to economically convert conventional drum-mix asphalt plants into units capable of recycling reclaimed asphalt pavements.
- Asphalt mixes containing RAP can be designed using conventional laboratory equipment and techniques.
- By using virgin aggregates and new asphalt cements to correct any deficiencies in the RAP, the resulting asphaltic concrete is equivalent in quality to mixes using 100% virgin products.

- A valuable recoverable resource exists in the Province's asphaltic concrete highways and streets.
- Recycling of asphalt pavements can produce significant savings in resources, energy, and construction budget dollars.
- Recycling of existing asphalt pavement will help reduce foreign oil dependency.
- Total removal of asphalt pavements for recycling should eliminate or postpone reflective transverse cracking prevalent with conventional overlay methods of highway construction. This will, in turn, extend the life of the pavement and reduce maintenance costs.

APPENDIX B: Asphalt Recycling Savings Calculator

With the one exception noted below, the "Asphalt Recycling Savings Calculator", a simple slide-rule type device available from Standard Havens, is straighforward in operation and accurate. It greatly simplifies the cost comparison between virgin and recycled asphalt mixes.

One variance which is not taken into account by the calculator is in Step (2). The calculator assumes that the design mix to be produced will have the same % A.C. content as the reclaimed asphalt. Should the A.C. content in the RAP, as in many cold milling projects, be higher than that required in the new mix, than the saving of asphalt cement per ton of new product will be greater.

In a project such as the McGivney demonstration where contamination by the sub-base material occurred with the total removal method of reclaiming, the A.C. content of the RAP (4.4%) was lower than required by the design mix (5.7%).

Using the calculator in this case would give a higher asphalt cement saving than was actually achieved. In cases where these variances occur, a correction factor would have to be taken into account.

Roadway Surface Showing Extreme Alligator Cracking & Distortion. The Existing 135 m.m. Thick Pavement Structure was Estimated To Have an Equivalency Factor of 0.4 Using the Asphalt Institute Rating System.

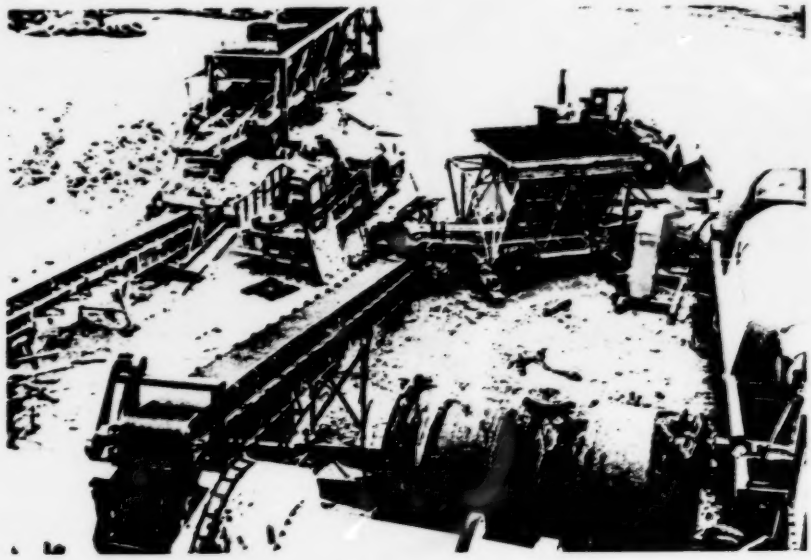
Single Tooth Mounted on Grader Scarifer Was Used to Rip the Old Asphalt Pavement.

Cat. 977 Crawler Loader With Side Dump Bucket Loaded Haul Units.

A Hewitt-Robbins Primary with a 76.2 cm Jaw followed by a Model 645 Cedar Rapids Super-Commander equipped with a 30.5 cm X 91.4 cm Twin Jaw and a 63.5 cm X 76.2 cm Roll made up the crushing train required to reduce the RAP to 100 percent passing a 38 mm seive.

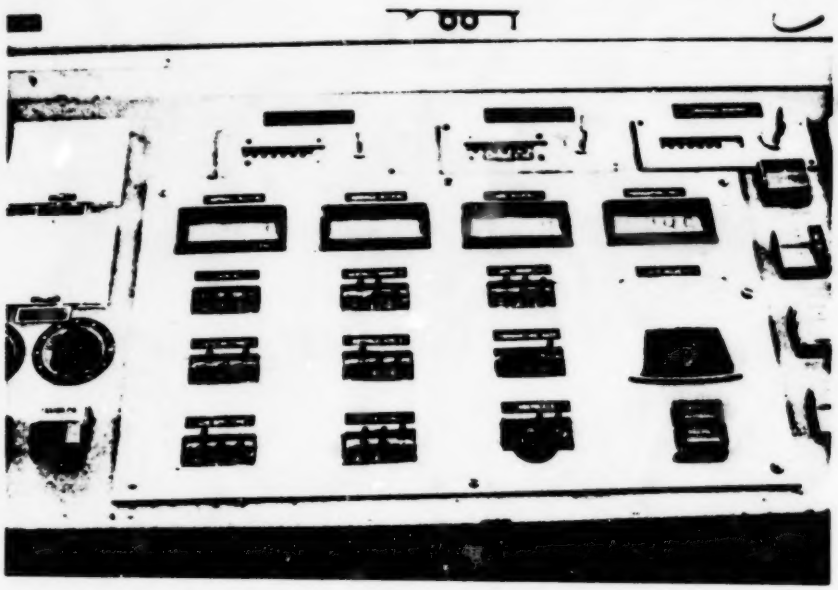
Cat. 950 loader feeds RAP to asphalt plant.

RAP stockpile approximately 30 m in height. Scrap tires were used to weigh down the 1026m^2 fiber-glass reinforced plastic tarp.



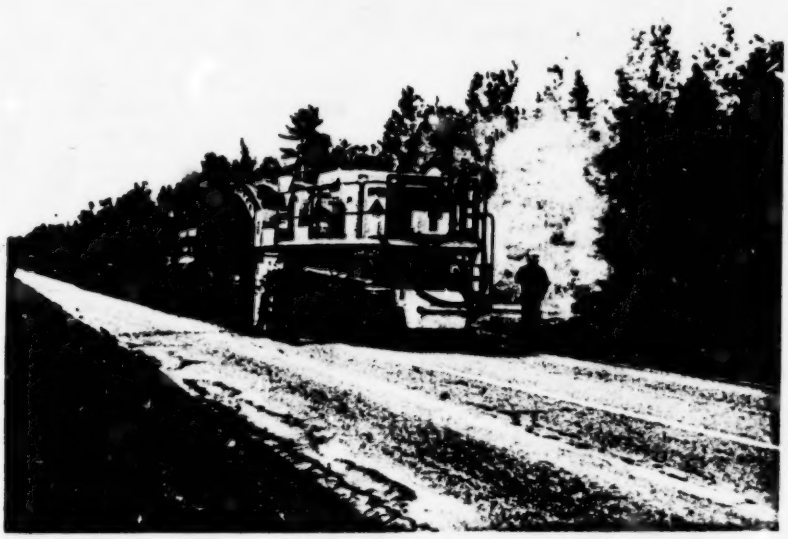
RAP feed components consisted of a 18.3 m X 76.2 cm conveyor with Ramsay load cell, and a feed bin. These units were designed and built by Eastern Paving Limited and Apex Industries Ltd., Moncton, N.B.

Feed chute and collar in place on the SA 836 drum mixer.



Data entry thumb-wheels and LCD digital displays were added to the plant control panel as part of the Modicon Programmable Controller. Plant controls were converted to SI units during the installation.

Asphaltic concrete base containing 50 percent RAP was placed in two lifts of 122 Kg/m^2. The mix contained aggregate up to 38 mm in size, however, no tearing of the mat was experienced from large stones.



Route # 11 Recycling Project. Miller Paving's CMI 750 Cold Planer removes 2" of cracked and broken asphaltic concrete from underlying cement-treated base.

Planer loading haul units during removal operation.

Standard compaction procedures were used. A 404 Raygo and a C50 Double Drum Dyna Pak were used for rolling.

Completed roadway after 33 mm surface course and lane stripping. Adjacent paving projects using Standard pavement overlay construction are showing reflective transverse cracking after only three years service.

Stockpiling of RAP carried out by clam bucket and front-end loader. Extensive compaction of RAP was experienced from pile height and loader tires.